IMPROVING FIBRE UTILIZATION IN THE ASPEN STRUCTURAL PANELBOARD INDUSTRY

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INTRODUCTION

This study examines the use of a Morbark Model 20 Chiparvestor mobile chipper as a system for recovery and processing of residual forest biomass into a form that is suitable for further processing and use as raw material for Waferboard/Oriented Strand Board (OSB) production.

The potential for application of the system to extend the fibre base and lower the per unit cost of fibre to existing OSB plants is investigated.

In a typical Aspen (Populus tremuloides) logging operation, only about 70 to 80% of the available solid wood fibre harvested is transported to the mill. The other 20 to 30% of the fibre remains in the forest in the form of tops, branches and otherwise non-merchantable wood. This material is normally piled and burned as waste.

This study examines the use of this waste as raw material for manufacture of reconstituted board products.

The report in Appendix 1 summarizes the work done at the Alberta Research Council (ARC) Forest Products Laboratory to manufacture and evaluate oriented test panels. Panels using ring flaked material in the core in the approximate proportion generated by logging residue were compared with panels made with 100% disc waferized strands. The physical/mechanical tests indicated that water absorption and thickness swell increased slightly, but the strength properties measured were not affected by the addition of the ring flaked material.

An additional 18% of the roundwood hauled from the logging site was recovered in the form of maxi-chips. The maxi-chip losses after screening out overs and fines, and assuming the overs are rechipped, should be about 12%. Thus, overall recovery of maxi-chips after screening that are suitable for ring flaking would be about 16% of the wood hauled.

At the present cost of roundwood delivered to the log yard, it would appear to be economically viable to chip the residual material as the savings are sufficient to payback the capital cost of the investment in about 2.3 years for a 44% return on capital invested.

There are also several other advantages that are of significance in utilizing the logging residue:

- the cost of burning the residue is eliminated
- the fines from the maxi-chip and strand screening operations would have value as fuel
- the total volume of useable fibre is increased.

CHIPPING OPERATIONS

The Morbark Model 20 Chiparvestor is built on a tandem axle semi-trailer with a pintle hitch. A fifth wheel hitch conversion is provided for highway hauling. The unit requires a powered haul unit for moving.

The machine was equipped with a single knife chipper disc with the knife configured in three sections and staggered at 120° around the circumference. Each knife section cuts one third of the radius of the disc. A special modification of the disc and projection of the knives was used to manufacture an oversized chip or "maxi-chip". This chip measured 2" to 3" long by approximately ½" thick. Width across the grain varied from 1/2" to 2".

The machine was powered by a 350 HP diesel engine. The model number 20 denotes the maximum opening size in inches for log input. An integral slide boom grapple loader was used to feed logs and trees into the spout.

The aspen trees were logged by conventional methods, including hand falling and feller-bunchers. Grapple skidders moved the tree length logs to a landing where a mobile slasher bucked the logs into 8 foot, 6 inch blocks. The grapple loader on the slasher piled the blocks to a height of about 15 feet. The undebarked short blocks (less than 8'-6") tops and branches were piled on the opposite side of the slasher. Logging trucks were loaded by another grapple loader and the blocks were hauled to the mill in Edson, Alberta.

The Chiparvestor was moved and set up at three different locations at the logging site to chip the undebarked short blocks, tops and branches left by the slasher. A Cat 941 B dozer with blade was used to move the Chiparvestor in the bush and to forward the residue (tops and branches) to the Chiparvestor.

The chipper disc was fitted with integral fan blades and the maxi-chips were blown directly into the chip van. The chip van, equipped with a moving floor for self dumping, transported the maxi-chips to the weigh scale and then dumped them at the screening site. The round trip of 50 miles took 1.5 to 2 hours, including weighing and dumping.

The Chiparvestor took 2 to 2.5 hours per van load of 19.5 tonnes.

The chipping operation was not set up to maximize productivity as this was not the objective of this study.

Several factors limited the productivity as follows:

a) Chip Vans -

Only one truck and van was used. This resulted in a 1.5 to 2 hour delay each time a van load had to be weighed and dumped. During this interval, maintenance and service was carried out on the Chiparvestor.

b) Chiparvestor -

The Model 20 Morbark did not have an infeed chain section. A Model

22 RXL which has this feature, would have resulted in a much higher productivity rate. Considerable time was lost trying to feed the short (less then 8'-6") blocks into the spout.

c) Cat 941 Dozer -

Delays in chipping resulted when the dozer had to forward the residue further than about 100 feet. This also caused considerable entangling of the tops and branches.

Only one knife change on the chipper was required after production of about 75 tonnes of maxi-chips. Under normal operating conditions, this would mean a knife change about every four hours.

MAXI-CHIP SCREENING

A temporary maxi-chip screening operation was set up in an unused portion of an Oriented Stand Board plant log yard in Edson. A production model B.M. & M. 5' x 12' rotary chip screen fed by a belt conveyor separated the "overs" and "fines" from the acceptable chips. A 4-1/2" x 4-1/2" square opening screen was used to separate overs and a 1/2" x 1/2" square opening screen was used to separate fines.

A belt conveyor was used to convey the acceptable chips into a 20 cubic yard dump truck box. The accepts, fines and overs were weigh-scaled to determine recovery factors (see Table 1).

Smaller openings in the fines screen would have been more suitable as a large portion of the fines, possibly 50% or more, appears to be acceptable material for ring flaking.

MAXI-CHIP PRODUCTION DATA

A total of 840.8 tonnes of logs were hauled from the three logging sites.

An additional 151.6 tonnes of chips were produced by the maxi-chipper from the residual tops and branches left at the three landings.

As shown in Table 1, this represents recovery of an additional 18.0% of usable wood in the form of chips.

TABLE 1
CHIP PRODUCTION / LOSSES / RECOVERY

Col 1	2	3	4	5	6	7
Site No.	Green Wt of logs hauled (tonnes)	Green Wt chips produced (tonnes)	Chips as % of wood hauled (%)	*Green Wt Acceptable chips (tonnes)	Screen Losses (%)	Acceptable chips as % wood hauled (%)
1	262.6	42.2	16.1	35.2	16.6	13.4
2	173.8	35.0	20.1	27.5	21.4	15.8
3	404.4	74.4	18.2	59.5	20.2	14.7
Total	840.8	151.6	18.0	122.2	19.4	14.5

*Through 4-1/2"x 4 - 1/2" square opening screen over 1/2" x 1/2" screen

A total of 122.2 tonnes of acceptable chips were recovered after screening off the "overs" and "fines". Screen losses from overs and fines amounted to 19.4% of the chips screened. We estimate this could be reduced to about 12% with rechipping and retention of more fine material.

Overall acceptable screened chips represent a 14.5% increase in recovery of usable wood from the forest. This percentage could be increased to about 16% with rechipping of overs and retention of more of the fines.

MAXI-CHIP RING FLAKING, DRYING AND SCREENING

An approximate 400 lb. sample of undebarked screened maxi-chips was flaked on a Pallmann PZ8 ring flaker at a nominal 0.026" thickness.

The flaked strands were dried in a rotary drum dryer to 3.5% moisture content dry basis. The material was then screened to separate out the fines fraction.

The material retained on the 4 mesh screen was shipped to Alberta Research Council Forest Products Testing Laboratory in Edmonton for test board manufacturing.

We had anticipated that a much higher percentage of strands would be retained on the 4 mesh screen. The PZ8 ring flaker at M.B. Research apparently contributed to the relatively high percentage of minus 4 mesh material, as was subsequently confirmed by tests on a PZKR-8 ring flaker at the equipment manufacturers R&D facility in West Germany.

Problems with the PZ8 ring flaker could be attributed to the following:

a) The small diameter of the PZ8 knife ring.

b) The relatively short knife length (5-3/4" long).

c) The rough gap which resulted by removing every other knife and filling the slot with a dull knife.

d) Lack of optimization of feed rate in relation to RPM of impellor and knifering.

Nevertheless, more than 80% of the material was retained on the 4, 6, 8 and 12 mesh screens. Most of this material has a length to width ratio of 3 to 1 or greater, and with proper orientation equipment would be suitable for the core of OSB.

Results of the strand screening operation at M.B. Research are shown in Tables 2 and 3.

TABLE 2
Aspen Maxi-Chip Flaked in Pallmann PZ8
Knife Setting 0.026"
(Flat Screen)

Bag No.	Weight (lbs)	% Accepts + 4 Mesh	% Fines - 4 Mesh	Comments
1	18	50.0	50.0	- Knifering 26 knives newly sharpened
2	17	44.1	55.9	
3	26	23.1	76.9	- Damaged knives (shut down)
4	25	48.0	52.0	- Knifering 13 newly sharpened knives
5	28	44.6	55.4	
6	23	43.5	56.5	
7	22	40.9	59.1	
8	35	41.4	58.6	
9	30	40.0	60.0	- Some dulling of knives
x	224	41.7 *44.0	58.3 *56.0	- Average M.C. of dried flakes 3.5%

*Averages excluding bag #3

TABLE 3
Sieve Analysis of Aspen Flakes
Flaked in a Pallmann PZ8 at a 0.026" Knife Setting
(Tyler Screen)

Bag	Tyler Mesh Size										
No.	4	6	8	12	16	20	30	40	100	-100	Total
1	37.3	17.7	15.7	13.2	7.8	4.7	2.2	0.6	0.5	0.2	99.9
9	32.4	16.6	16.1	15.2	10.2	5.7	2.4	1.2	0.5	0.2	100.0

Due to the poor test results obtained at M.B. Research on their PZ8 ring flaker, a decision was made to ship a representative sample of maxi-chip to Pallmann, the equipment manufacturer, in West Germany for processing at their R&D facilities. A model PZKR-8 ring flaker was used to flake the sample of maxi-chips under more optimum conditions. The test results are as follows:

	Screen Opening	% Retained
Above	20 x 20 mm	20.5
Above	16 x 16 mm	13.0
Above	10 x 10 mm	17.3
Above	6.3 x 6.3 mm	7.0
Above	4.0 x 4.0 mm	6.8
Above	3.15 x 3.15 mm	4.8
Above	2.5 x 2.5 mm	4.1
Above	2.0 x 2.0 mm	3.8
Above	1.4 x 1.4 mm	5.9
Above	1.25 x 1.25 mm	2.3
Above	0.8 x 0.8 mm	5.7
Below (Pan)	0.8 x 0.8 mm	8.5

Where:
4 Mesh = 4.75 x 4.75 mm
6 Mesh = 3.35 x 3.35 mm
8 Mesh = 2.4 x 2.4 mm
12 Mesh = 1.4 x 1.4 mm
16 Mesh = 1.0 x 1.0 mm
20 Mesh = 0.84 x 0.84 mm

A total of 64.6% of the material was retained above the 4.0 x 4.0 mm screen opening. This compares to the 32 to 37% retained on the 4 mesh Tyler Screen at M.B. Research (see Table 3).

However, a production model PZKR-12 or 14 ring flaker, should produce a significantly better strand with far less fines. Therefore, our economic analysis is based on the assumption that 80% of usable strands will be recovered for use in the core of the board.

LAB SCALE BOARD

Production

Two sets of panels were manufactured at the Alberta Research Council Forest Products Laboratory. The first set of twenty panels was a control using all disc waferized strands in a three layer board. The second set of twenty panels used disc waferized strands in the outer layers and a mixture of disc waferized strands and ring flaked material (70:30) in the core. This proportion gave the treatment set an overall ratio of 88% disc waferized strands and 12% ring flaked strands.

Testing

Physical mechanical testing was carried out according to CAN3-0437.1-M85 (Test Methods for Waferboard and Strandboard).

Each set of twenty panels was randomly divided into two parts; one group of 10 for testing parallel to surface layer orientation and the other group of 10 for testing perpendicular to surface layer orientation.

The following tests were conducted:

- density
- moisture content (MC)
- Modulus of Rupture (MOR)
- Modulus of Elasticity (MOE)
- Internal bond (IB)
- Water absorption

Results

Test results indicate that strength properties were not affected by the addition of ring flaked material in the core of the board. Water absorption and thicknesses swell increased slightly.

A copy of the complete test report is contained in Appendix 1.

ECONOMIC ANALYSIS OF CHIPPING AT THE LOGGING SITE

Based upon data collected during the five day field test run using the Model 20 Morbark Chiparvestor to produce maxi-chips and the screen to separate fines and overs, we have made the following economic projections using a Model 22 Chiparvestor:

Capital Cost Estimate

	$ Can
Morbark Chiparvestor Model 22	325,000
Freight and Spares	20,000
Screen - portable	50,000
Freight and Spares	6,000
Cat D-4 Dozer with blade	90,000
Freight and Spares	9,000
Total Equipment	500,000

Typical Operating Cost Estimate

Fixed Costs:

Equipment and tools are capitalized over a ten year period.

		$/Year
a) Materials and tools:		
- Service truck c/w portable welder		
$20,000 ÷ 10 years	2,000	
- Tools $10,000 ÷ 10 years	1,000	
		3,000
b) Other Costs:		
- Administration, Supplies, Telephone		500
- Insurance (1% of average value)		2,400
- Depreciation (500,000 ÷ 10)	50,000	
- Interest 13% x 500,000		65,000
		$117,900
Total Fixed Costs		$120,900

c) Fixed Costs per Hour of operation

120,900 ÷ 3,000 hour/year =	$40.30/hour

Variable Costs

a) Labour - Operating

250 days/year @ 12 hours/day

2 operators x $15/hour x 3,000 hours		$90,000
1 helper x $12/hour x 3,000 hours		36,000

b) Labour - Maintenance

20 hours per week by 1 operator and

a helper at 1.5 x normal rate

Operator:		
= 50 weeks x 20 hours/wk x 1.5 x $15	=	22,500
Helper:		
= 50 weeks x 20 hours/wk x 1.5 x $12	=	18,000
		$166,500
Fringe Benefits - 20%		33,300
Total Labour		$199,800

c) Supplies, Parts and Fuel

Supplies and Parts:		
$15/hour x 3,000 hours		45,000
Fund for engine overhaul:		
$2.00/hour x 3,000 hours		6,000
Diesel Fuel - Chipper and Dozer		
20 gph x $1.80/gal x 3,000 hours	=	108,000
Total Supplies and Diesel		159,000
Total Variable Costs		$358,800

d) Variable Costs per Hour

$358,800 ÷ 3,000 hours = 119.60/hour

Operating Cost Summary

	$/hour
Fixed Costs	40.30
Variable Costs	119.60
Total Cost Per Hour	$159.90

Maxi-Chips Production and Cost Per Tonne

A Model 22 Morbark Chiparvestor with a disc suitably modified to cut maxi-chips should be able to process a van load of 19.5 tonnes in about one hour. With adequate support equipment consisting of at least two spare vans and a bull-dozer, the only non-productive time would be as a result of the following:

- mechanical breakdowns
- refueling time
- knife changes
- moving the chipper to a new site
- waiting for dozer to forward aspen residual to the chipper
- waiting for a chip van.

Screen losses based upon our experience at Edson were 19.4%. We estimate at least 40% of the 19.4% would be recoverable as acceptable chips after rechipping of the overs and retention of more of the fine material which was screened out. Therefore, we believe screen losses to be only about 60% of the 19.4%, or approximately 12% of the total chipped wood.

Chip production after screen losses would then be:

19.5 tonnes/hour - 12% of 19.5 tonnes/hour or 17.2 tonnes/hour

Total production cost per tonne in the landing would then be

$159.90/hour ÷ 17.2 tonnes/hour = <u>$9.30/tonne</u>

Assuming a contract cost of $50.00/hour per truck and a two hour return trip time (50 miles round trip), two trucks can handle three vans.

Assuming a net load of 17.2 tonnes of usable chips after screening, per van load, the round trip hauling cost would be:

$$\frac{2 \text{ trucks} \times 12 \text{ hours/day} \times \$50\text{/hour/truck}}{12 \text{ loads/day} \times 17.2 \text{ tonnes/load}} = \$5.81\text{/tonne}$$

<u>Total Cost</u>

Total cost of maxi-chips into the plant site would be:

- Chip production	$ 9.30/tonne
- Hauling costs	$ 5.81/tonne
Total Costs	$15.11/tonne

TABLE 4
RAW MATERIAL REQUIREMENTS/MSF 3/8"
INPUT ASSUMPTIONS FOR AVERAGE 3/8" BOARD THICKNESS
(Conventional Roundwood Mill)

Input/MSF Assumptions	Units	%	Amount
Finished Board Wood Only at 41.5 lb/ft^3	OD LB/MSF	-	1,297
Saw Trim Loss to Full Size Board	OD LB/MSF	9.6	138
Wood and Chemicals to Press	OD LB/MSF	-	1,435
Wax Additives	Lbs. Solids/MSF	1	14
Resin Additives	Lbs. Solids/MSF	2	28
Wood to Blender	OD Lb/MSF	-	1,393
Plant Fiber Losses at Dryer and Screens	OD Lb/MSF	20	348
Wood to Flakers Dryers and Screens	OD Lb/MSF	-	1,741
Log Yard Losses	OD Lb/MSF	3	54
Wood to Process or Net Wood Input	OD Lb/MSF	-	1,795

Total Wood Input:

$$\frac{\text{200,000 MSF 3/8 /Year x 1,795 OD LB/MSF}}{\text{2,204 LB/Tonne}} = \text{162,886 OD Tonnes/Year}$$

Rounded 163,000 OD Tonnes/Year

Comparison of Wood Costs to the Log Yard

All roundwood versus roundwood and ring flaked maxi-chips for the core.

Assumptions

- Gross OSB plant capacity	=	200,000 M 3/8 per year
- Plant roundwood requirements (from Table 4)	=	163,000 OD Tonnes/Year
- Roundwood unit cost	=	\$20.00/Tonne
- Wood left after logging suitable for maxi-chips (see Table 1)	=	18.0%
- Cost of wood for maxi-chips	=	NIL
- Wood losses from green screening	=	12%
- Chip supply for core of board after losses as a percent of the total = 88% of 18%	or	16%
- Cost of maxi-chipped wood into plant storage	=	\$15.11/Tonne

Conventional All Roundwood Costs:

- Weight of OD Wood	=	163,000 tonnes/year
- Weight of green wood equivalent at 100% MC dry basis	=	326,000 tonnes/year
Annual roundwood cost = 326,000 x \$20/tonne	=	\$6,520,000

Combination Roundwood and Maxi-Chipped Wood Costs:

In order to utilize the wood available from forest residue, we must adjust the total quantities logged to represent their corresponding proportions.

If 16% additional wood is available, then the total available is now 116%.

The proportion of roundwood to maxi-chips would then be:

Roundwood: $\frac{100}{116} \times 100\% = 86.2\%$

Maxi-chipped Wood: $\frac{16}{116} \times 100\% = 13.8\%$

- Roundwood Cost:
  326,000 tonnes/year x 0.862 x $20.00/Tonne = $5,620,240

- Maxi-Chipped Wood Cost:
  326,000 tonnes/year x 0.138 x $15.11/Tonne = 679,768
  Total $6,300,008
  Rounded $6,300,000

Savings:

Potential Savings in wood costs in to the yard =
$6,520,000 - $6,300,000 = $220,000/year

It would appear to be economically viable to chip the residual material, as the savings are sufficient to pay back the capital cost of the machinery and equipment in about 2.3 years.

The above analysis does not include any capital or operating costs for equipment to process the maxi-chips into useable strands.